TIME DEVELOPMENT OF LOCAL SCOUR DEPTH BELOW PIPELINES EXPOSED TO WAVES

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AIM OF THE STUDY

The aim of this study is to find an empirical formula to predict the time development of local scour below a pipeline laid on an erodible bed. This paper is a part of ongoing research projects investigating the scour below submerged pipelines due to regular waves. These projects cover the range of the following topics: equilibrium scour depth, time-dependent scour depth, time scale of scour process, scour development along the pipe, and scour protection. This poster contains only the second phase of the research mentioned above. A specific empirical relationship for computing the "Temporal Variation of Scour Depth" (Figure 1) was derived from the experimental data.

MATHEMATICAL BACKGROUND

The book by Sumer and Fredsøe (2002) is the most significant literature, which covers all research in this field, until its publication date. In their book, they stated that the time variation of scour depth can be represented by the following formula

\[ S_t = S_e - e^{-(t/T_{DU})} \]  

(1)

in which \( S_t \) is the time dependent scour depth, \( S_e \) is the equilibrium scour depth, \( t \) denotes time, and \( T \) is the “time scale” of the scour process. Sumer and Fredsøe also indicated that Keulegan-Carpenter number (KC) and Shields parameter (\( \theta \)) are the most important governing parameters for dimensionless analysis of the time-development of local scour under the wave conditions.

\[ KC = \frac{U_m T_w}{D}, \quad \theta = \frac{u^*}{g(S_t - D)} \]  

(2), (3)

where, \( U_m \) is the maximum value of the velocity of the orbital motion of water particles at the pipe axis, \( T_w \) is the period of wave, \( D \) is the pipe diameter, \( U_m \) is the maximum value of bed shear velocity, \( g \) acceleration due to gravity, \( s \) specific gravity of sediment grains, and \( D \) is the grain size.

EXPERIMENTAL SET-UP AND PROCEDURE

The experimental test program was conducted in a wave channel 33 m long, 3.6 m wide and 1.2 m deep (Figure 2). The wave channel has a plunger type wave generator at one end, and a sloping wave absorber at the other end to eliminate reflection waves. Adjustment of input wave parameters was maintained with the aid of an electronic pitch control unit. The horizontal water particle velocity in the pipe axis, time-dependent scour depths, \( T_w \) and \( U_m \) values were determined through an Ultrasonic Velocity Profiler (UVP) device and an Ultra Lab System (ULS), their transducers and associated software (Figure 3).

RESULTS

A review of the experimental data has shown that the time development of scour depths underneath the test pipe area is coming into sight with two phases (developing and equilibrium stages), similar to the previous studies. \( D_n \) non-dimensional time dependent scour depth for the live-bed scour regime can be represented by least-square fit;

\[ S_t = \frac{D}{0.0012 \times 2^{K C^2 + 0.12} \theta^{1/2}} \left(1 - e^{-0.001t} \right) \]  

(4)

where \( t \) denotes the non-dimensional time variable as it is described below,

\[ t = \frac{D}{U_m T_w} \]  

(5)

Some actual measurements and calculated values from Eq.(4) are plotted in Figure 4.

CONCLUSION

The experiments has revealed that scour process below a submerged pipe is dominated by both Keulegan-Carpenter number and Shields parameter. An empirical relationship, which includes these well-known dimensionless numbers, has been suggested to describe the temporal variation of scour depth below pipelines due to regular waves. Thus, the characteristics both of incident wave and bed material can be adapted easily to the computation of time dependent scour depths by way of these parameters. The proposed formula is valid only for the live-bed regime; but the selection of a wide range of the grain sizes of bed materials can be considered as a contribution to the study of the scour below pipelines.

REFERENCES


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• DEU Engineering Faculty Hydraulics Laboratory Researchers and Staff

Table 1. The summary of the experimental data and calculated data

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<th>T (s)</th>
<th>F (Hz)</th>
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<th>( U_m ) (m/s)</th>
<th>( S_e ) (m)</th>
<th>( S_t ) (m)</th>
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Figure 1. The variation of the scour depth with time

Figure 2. Pictures and schematic description of the experimental set-up

Figure 3. Position of the ultrasonic devices used in the present study

Figure 4. Time development of scour depths.